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ANALYSIS OF LONG-TERM DATA ON URANIUM IN AIR

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ABSTRACT

The Oak Ridge Y-12 Plant, primarily a manufacturing facility geared to the fabrication and processing of uranium into components to fulfill the nuclear weapon defense needs of the United States, maintains positive engineering control to reduce uranium airborne activity to a safe and acceptable level in the working environment.

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SUMMARY

Plant operations at Y-12 are under positive engineering control to reduce uranium airborne activity to acceptable levels. This control is maintained through. (1) monitoring the radioactive effluents from exhaust stacks, (2) determining the level of radioactivity in liquid effluents, (3) studying particle-size characteristics, and (4) controlling those factors that pertain to personnel exposure.

INTRODUCTION

The main function of the Oak Ridge Y-12 Plant's^(a) uranium processing areas is to convert raw materials to rough shapes suitable for machining and finishing to an exact configuration. The Plant also recycles waste materials generated by the various manufacturing processes. The processes which have been selected for discussion are those where long-term experience has demonstrated that positive engineering techniques are required for effective control of uranium airborne activity in the working environment and in the outside environs. These operations are (as they pertain to those areas where enriched uranium is processed): (1) reduction of UF_4 to metal, (2) casting, (3) rolling and forming, (4) machining, (5) wet chemistry recycle, and (6) UF_4 extraction. In the work with depleted uranium, the rolling and forming and foundry operations are of primary concern.

(a) Operated by the Union Carbide Corporation's Nuclear Division for the US Energy Research and Development Administration.

ANALYZING LONG-TERM URANIUM DATA

PLANT OPERATIONS

Enriched Uranium Processes

Reduction of UF_4 to Metal - Reduction of UF_4 to uranium metal is performed in the facility shown in Figure 1. This facility consists of a variety of ventilated enclosures that range in type from absolute-filtered, inlet glove boxes to open-face hoods with a minimum face velocity of 120 linear feet per minute. The general-air and permanent-operational air samplers for this process for the last seven years revealed results well below the recommended levels for occupational exposure, as given in Figure 2.



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Figure 1. ENRICHED URANIUM REDUCTION FACILITY.

Casting - The uranium casting facility is well designed, self contained, and under a negative pressure of 0.5 inch of water in relation to the working environment. The working environment is also under negative pressure in relation to the surrounding process areas, thus providing double containment for the casting area. All casting operations are performed by remote control. The general-air and permanent-operational air sampler results reveal acceptable levels for the past seven years, as reported in Figure 3.

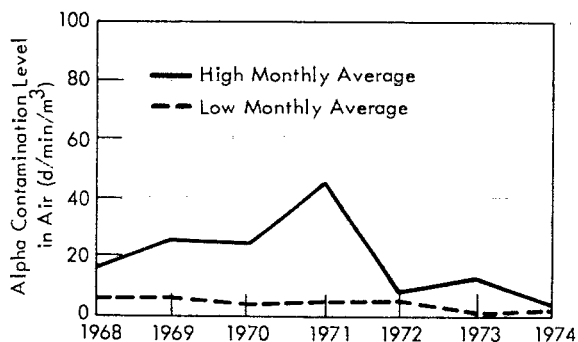


Figure 2. TRENDS IN THE LEVELS OF AIR CONTAMINATION DURING REDUCTION OF URANIUM TETRAFLUORIDE TO URANIUM METAL. (Enriched Uranium)

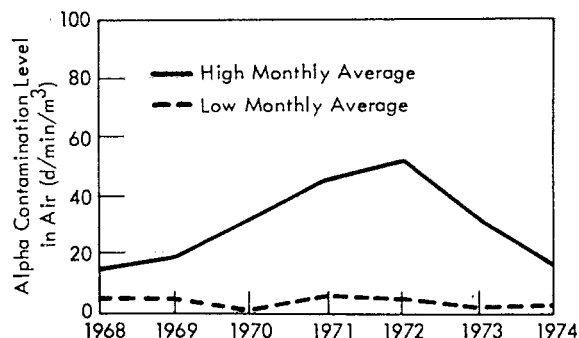


Figure 3. TRENDS IN THE LEVELS OF AIR CONTAMINATION DURING URANIUM CASTING OPERATIONS. (Enriched Uranium)

Rolling and Forming - The rolling and forming area, seen in Figure 4, is much like the casting area from a ventilation standpoint. All operations are performed by remote control. Air-sample data from these operations reveal excellent control, as given in Figure 5.



Figure 4. ENRICHED URANIUM ROLLING AND FORMING FACILITY.

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Machining - Machining of enriched uranium requires that the operation be performed wet, with a suitable machine coolant (low hydrogen content) and partial hood enclosure with a

linear face velocity of 150 feet per minute. A view of a typical machine setup, equipped with a hood and exhaust prefilter and a demister unit, is presented in Figure 6. Air-sample results (Figure 7) reveal excellent control of airborne activity except for one month in 1971. This problem was caused by a fire in the machine-tool exhaust air system, resulting in the automatic shut down of the exhaust air. Because the shut down was automatic, there was no release to the atmosphere.

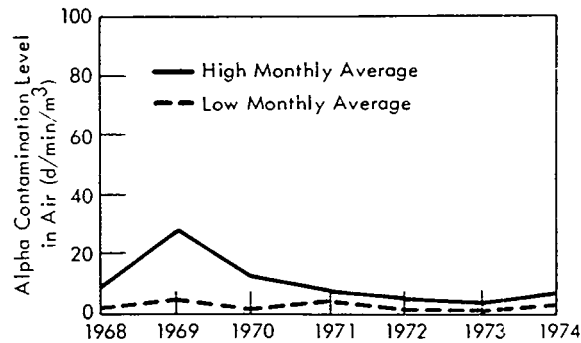


Figure 5. TRENDS IN THE LEVELS OF AIR CONTAMINATION DURING ROLLING AND FORMING OPERATIONS. (Enriched Uranium)

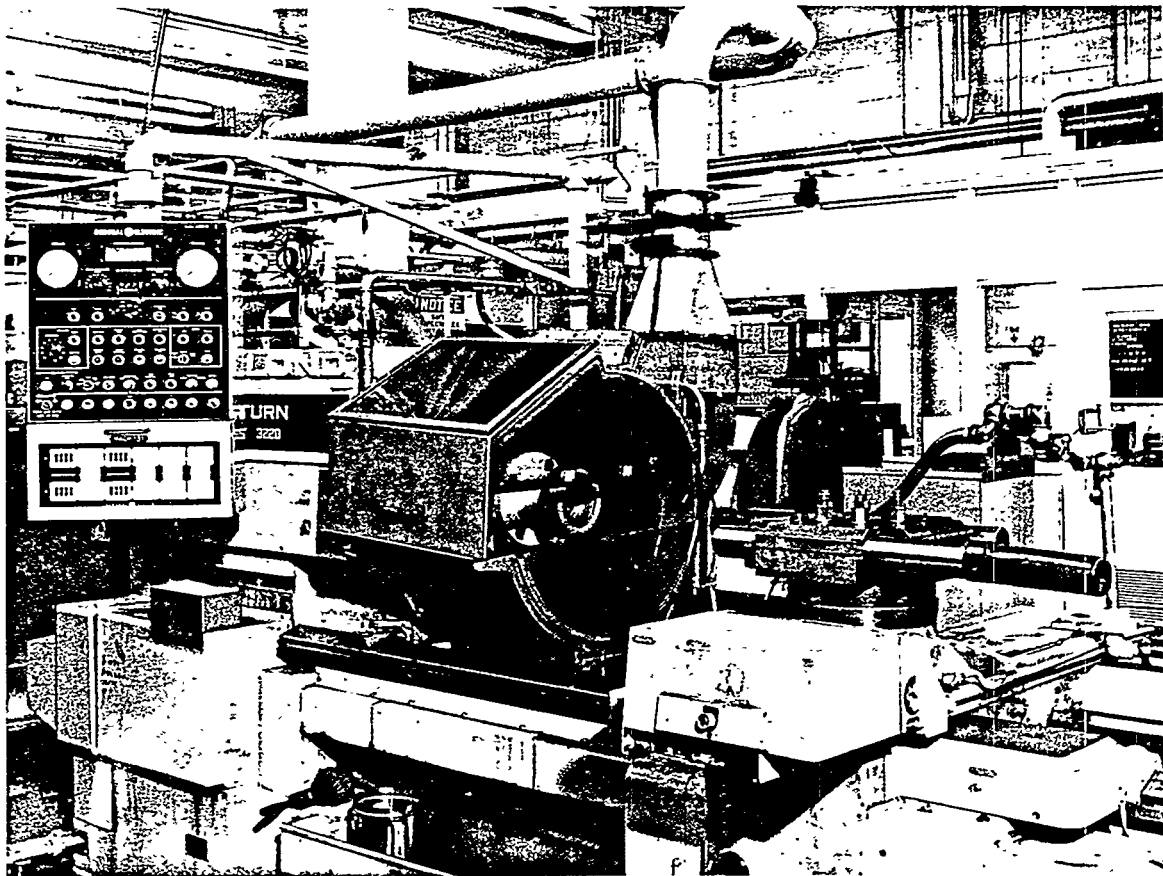


Figure 6. ENRICHED URANIUM MACHINING FACILITY.

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Wet-Chemistry Recycle Not all enriched uranium requires chemical processing. Very pure unalloyed uranium may be broken up and recast. Chips from the machine shop are briquetted and also recast. Alloys and less-pure uranium metal and oxides are dissolved and may then enter the chemical stream according to their concentration and purity.

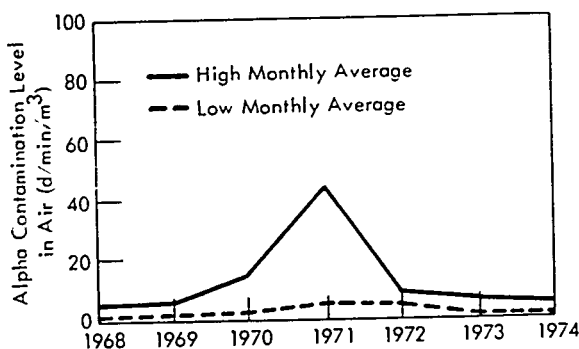
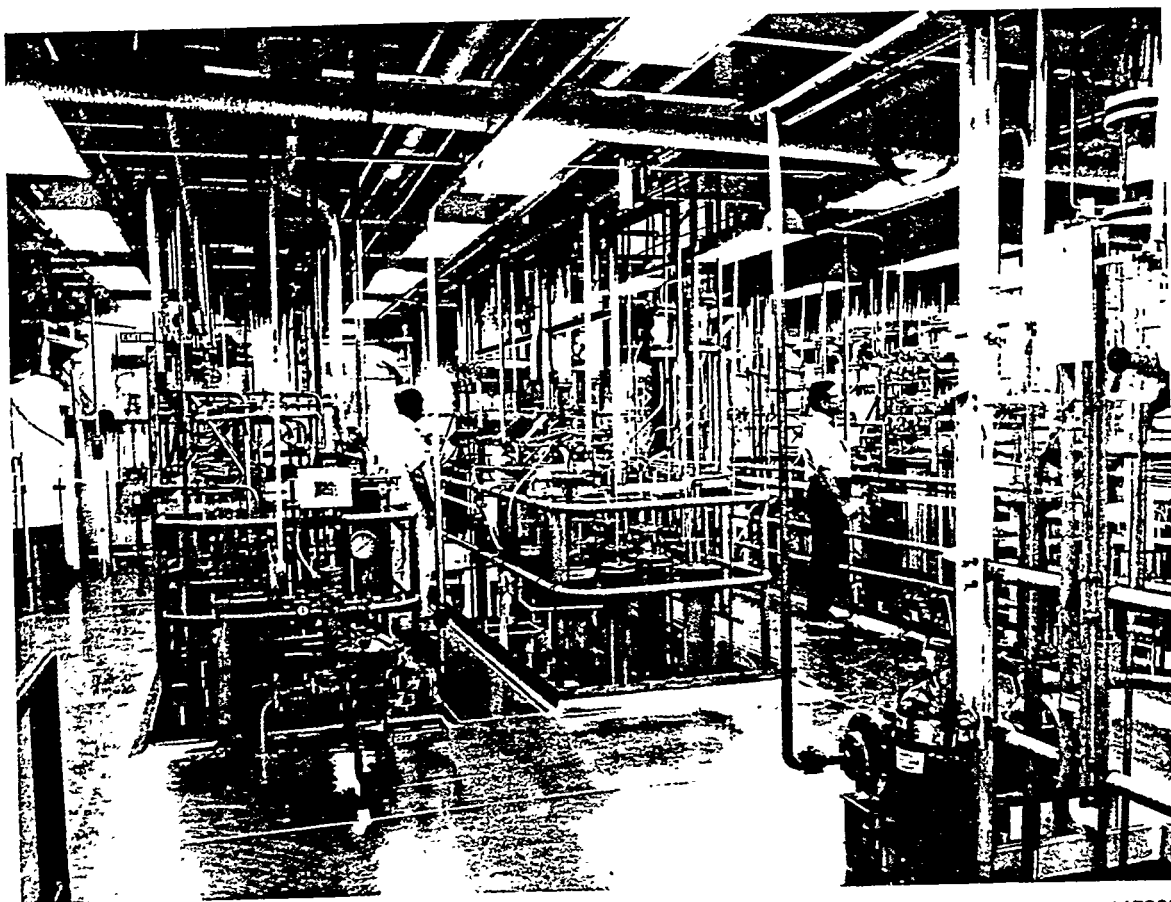


Figure 7. TRENDS IN THE LEVELS OF AIR CONTAMINATION DURING URANIUM MACHINING. (Enriched Uranium)

Combustibles, such as impure metal chips, mops, cloth and paper wipes, and carbon molds, are incinerated. These materials are burned in special burners that have absolute exhaust filters that discharge to a monitored stack. The ash from the burners is leached with nitric acid to recover the uranium in a process which looks like a "plumber's nightmare" (Figure 8). Since 1968, many improvements have been made to improve the control of airborne activity in the uranium recovery and recycle processess (Figure 9). Accomplishment of this objective can be attributed to process improvement, ventilation changes, improved procedures, and training of personnel.



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Figure 8. WET-CHEMISTRY RECYCLE RECOVERY AREA.

UF₄ Extraction - Pure uranyl nitrate produced in the recycle area is denitrated to uranium trioxide (UO₃) by heating. The resulting fumes are scrubbed in nitric acid to recover the

uranium and to decrease the output of the oxides of nitrogen (NO_x). The UO_3 is reduced to uranium dioxide (UO_2) with hydrogen and then is converted to the tetrafluoride (UF_4). The UF_4 is removed through a well-designed glove box line that contains an interlock system that permits container cleaning and bagging before removal. Figure 10 summarizes the uranium airborne data from the UF_4 production facility.

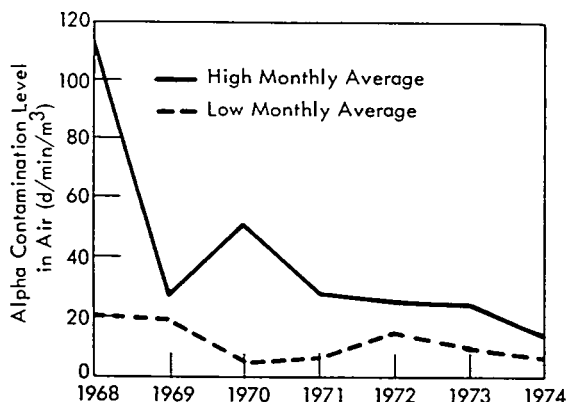


Figure 9. TRENDS IN THE LEVELS OF AIR CONTAMINATION DURING WET-CHEMISTRY RECYCLE OPERATIONS. (Enriched Uranium)

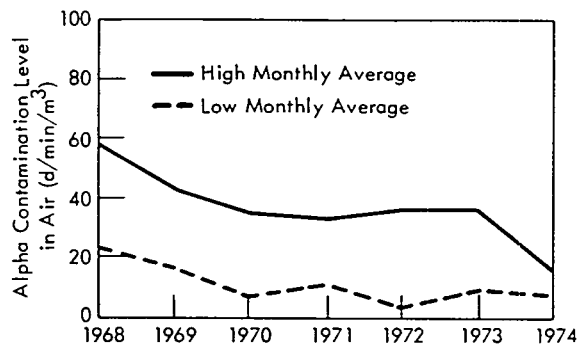


Figure 10. TRENDS IN THE LEVELS OF AIR CONTAMINATION DURING THE EXTRACTION PROCESS (UF_4 Production)

Depleted Uranium Processes

Rolling and Forming - Rolling and forming of depleted uranium requires some degree of control from a health standpoint. As seen in Figure 11, the rolling mill is equipped with up-draft and down-draft ventilation, since the operation is performed dry without the benefit of a coolant. The data, as given in Figure 12, reveal levels of uranium airborne activity well below an acceptable level in the working environment. Forming operations, as noted in Figure 13, require local ventilation around the press; due, primarily, to the preheat of the metal before and during the operation.

Casting - Casting of depleted uranium is performed in a closed system except for the removal of the cast shape. The knockout of these shapes is performed under positive engineering controls. A very strong vacuum system is used for the removal of the oxide from the casting and carbon from the molds. This operation is also performed on a grid with down-draft ventilation. Results of the effective control of uranium airborne activity from the operation are reported in Figure 14.

ENGINEERING CONTROLS

Radioactive Effluent from Exhaust Stacks

The Y-12 Plant has approximately twenty-five million dollars invested in the exhaust cleaning facilities for the process areas. These facilities consist of 95% efficient and 97.97% high-efficient particulate absorbers (HEPA), tested to 0.3 micrometer every six months by the DOP technique. All 59 discharge points are sampled continuously by isokinetic samplers in order to detect a malfunction of the system between tests. The total radioactive discharge to the atmosphere for 1974 was 0.085 curie, as measured by these samplers. As noted in

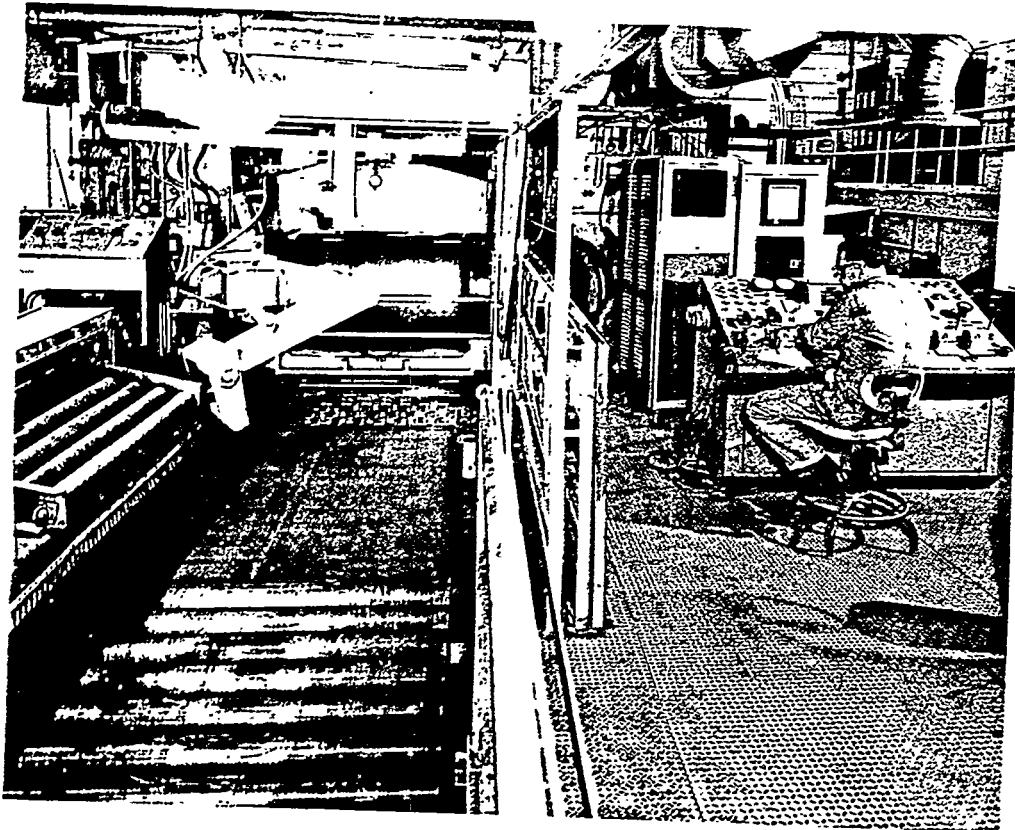


Figure 11. ROLLING A BILLET OF DEPLETED URANIUM.

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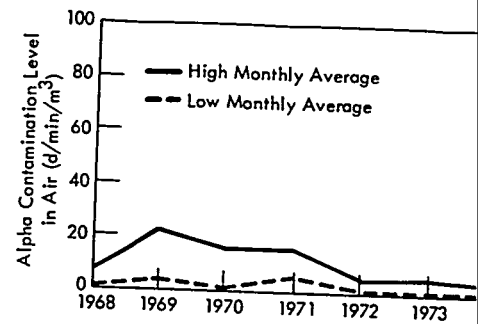


Figure 12. TRENDS IN THE LEVELS OF AIR CONTAMINATION DURING THE ROLLING AND FORMING DEPLETED URANIUM.

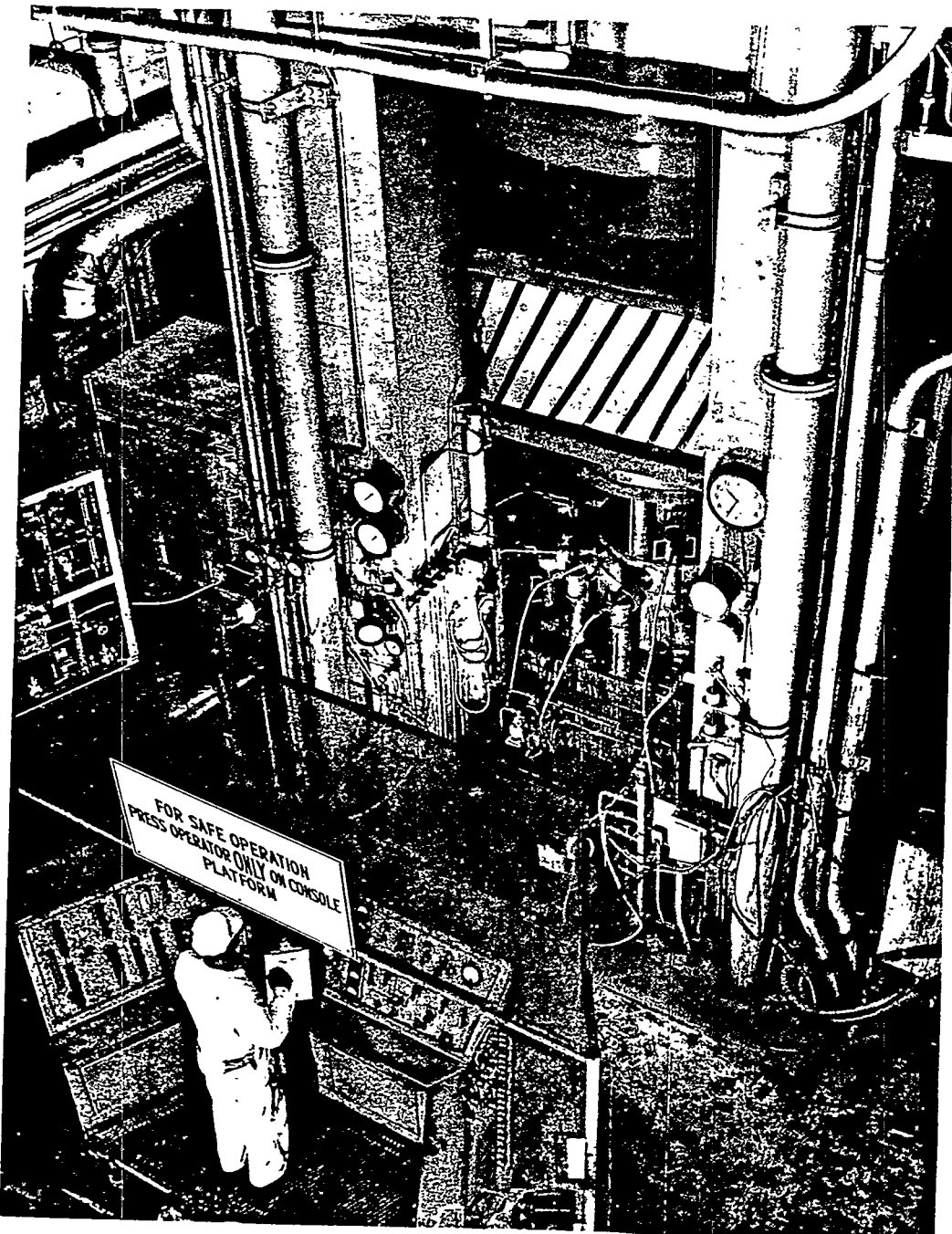


Figure 13. PRESS FOR FORMING DEPLETED URANIUM.

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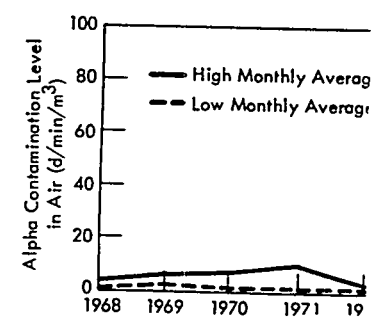


Figure 14. TRENDS IN THE LEVELS (CONTAMINATION DURING FOUNDRY OPERATIONS) (Depleted Uranium)

Table 1, the remarkable reduction in the amount of uranium discharged to the atmosphere can be attributed to a one-million-dollar upgrading of one exhaust cleaning facility in the latter part of 1973.

Table 1
RADIOACTIVE EFFLUENT FROM THE DISCHARGE STACKS

Total Number of Release Points	Total Discharged/Year (Ci)						
	1968	1969	1970	1971	1972	1973	1974
60	0.35	0.35	0.40	0.33	0.36	0.36	0.085 ⁽¹⁾

(1) Reduction due to improvements and modification of the exhaust system.

Radioactivity in Liquid Effluent

Once-through process cooling water, blow down from the cooling towers, and outflow from the storm sewers are discharged via New Hope Pond into the East Fork of Poplar Creek. New Hope Pond, which is a mixing and settling basin, is a man-built retention pond consisting of 29 water acres. The inlet and outlet of the pond are sampled by proportional samplers which provide samples for radioactive analyses. The uranium alpha activity analysis from these samples, as given in Figure 15, reveals results well below the recommended levels of the International Commission on Radiological Protection (ICRP).

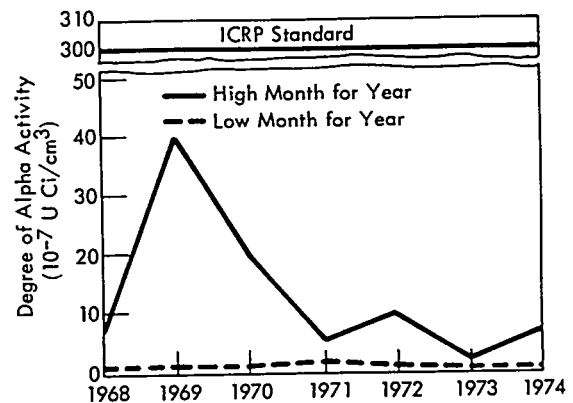


Figure 15. TRENDS IN THE LEVELS OF URANIUM ALPHA CONTAMINATION IN THE LIQUID EFFLUENT FROM THE Y-12 PLANT.

Particle-Size Characteristics

Samples collected by a modified cascade impactor were collected at various operations in the uranium processing areas (summarized in Table 2). Each stage of the impactor was counted for gross alpha activity. Particle-size determinations were made with an electron microscope. These results reveal that foundry operations (which produce uranium oxides) produce the highest percentage of airborne particles in the lower lung-inhalation range, while the wet machining and reduction operations (UF₄ to metal) have the smallest percent of particles. Therefore, the degree of positive engineering control required can be dictated by a particle-size analysis.

Personnel Exposure Factors

The real proof of how effective a program is in controlling the level of uranium alpha airborne activity in the working environment is best determined by an evaluation of an employee's internal exposure. Table 3 gives a summary of Y-12's experience for the past seven years through in vivo and urinalysis measurements. Metal preparation, which includes such operations as recycle, reduction, and casting, reveals, as might be anticipated, the area

where sound engineering controls are a necessity. In machining and support groups, the degree of containment is much easier to implement.

Table 2
SIZES OF AIRBORNE URANIUM PARTICLES IN THE PROCESS AREAS

Operation(1)	Mass Median Diameter(2) (μm)	Standard Deviation	Percent Activity from < 7 μ Particles
Foundry			
Depleted Uranium	2.8	2.7	88
Enriched Uranium (Sample 1)	3.3	2.2	
Enriched Uranium (Sample 2)	2.1	2.0	
Machining			
Depleted Uranium			
Machining with Coolant	2.0	2.0	
Polishing Wet and Dry	2.6	2.4	
Milling Dry	3.0	2.3	
Enriched Uranium			
Machining with Coolant (Sample 1)	1.9	2.2	16
Machining with Coolant (Sample 2)	1.6	2.3	
Extruding Depleted Uranium	3.2	2.7	18
Welding Depleted Uranium	1.6	3.4	
Reducing Enriched UF_4 to Metal	2.3	2.1	
Converting Enriched UF_6 to UF_4	1.1	2.0	

(1) Samples taken with a cascade impactor.

(2) Particle-size determination by electron microscope.

Table 3
URANIUM INTERNAL MONITORING

Process	Number of Employees in the Monitoring Program	Percent of ICRP Limit						
		1968	1969	1970	1971	1972	1973	1974
Metal Preparation	325	18	21	23	22	30	19	18
Machining	400	6	5	10	8	10	10	10
Other	950	6	6	11	10	8	12	10

CONCLUSIONS

The data presented show that the Y-12 Plant has been very successful in maintaining an effective program for the reduction and control of personnel exposure to uranium airborne activity to the lowest practicable level in the working environment.

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